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## NORTH AMERICAN SPECIES OF ALEURIA AND ALEURINA

(WITH PLATES 142-144, CONTAINING 10 FIGURES)

FRED J. SEAVER

The genus *Aleuria* was founded by Fuckel, and originally comprised the two species *Aleuria aurantia* (Pers.) Fuckel and *Aleuria rhenana*, the latter species described by the author of the genus. The genus has been used in various ways but in recent years has come to be restricted by some writers to the reticulate-spored species of *Pezizeae* and in this sense it is here employed. Four such species are known to North America, all of which are characterized by the bright orange color of the hymenium with the whitish exterior. The habitats of the four species are quite distinct and three of these are shown in the accompanying photographs.

*Aleurina* was used by Saccardo as a subgenus of *Phaeopezia* and differs from *Aleuria* in that the spores are colored. While the reticulations in the spores of the type species are less distinct than in the various species of *Aleuria*, there is a strong resemblance between the markings of the spores of the various species of *Aleuria* and the type species of *Aleurina*, which is here regarded as a distinct genus. *Peziza retiderma*, which was made the type of Saccardo's subgenus, was originally described from material collected at Portland, Maine. Recent collections of this species at Portland, Connecticut, has furnished material for the accompanying illustrations and descriptions.

[MYCOLOGIA for September, 1914 (6: 221-272), was issued September 26, 1914.]

## ALEURIA Fuckel, Symb. Myc. 325. 1869

Plants gregarious, scattered or cespitose, sessile or stipitate, fleshy, bright-colored, smooth or clothed externally with delicate white mycelium; asci cylindric, 8-spored; spores ellipsoid, at first smooth, at maturity reticulate.

Type species, *Peziza aurantia* Pers.

Spores not marked with ring at either end.

Plants sessile, at maturity large, reaching a diameter of several cm.

*A. aurantia*.

Plants stipitate, medium-sized, seldom exceeding 1 or 2 cm. in diameter.

Plants occurring in coniferous woods, stems usually long and springing from a dense mass of white mycelium.....*A. rhenana*.

Plants occurring among mosses in deciduous woods, stems short and not springing from a dense mass of white mycelium....*A. rutilans*.

Spores marked with a ring at either end.....*A. bicucullata*.

## ALEURIA AURANTIA (Pers.) Fuckel, Symb. Myc. 326. 1869

*Elvela coccinea* Schaeff. Fung. Bavar. 4: 100. 1774. Not *Elvela coccinea* Scop. 1772.

*Peziza coccinea* Bull. Herb. Fr. pl. 474. 1789.

*Helvella coccinea* Bolton, Fungi Halifax 3: 100. 1789.

*Peziza aurantia* Pers. Obs. Myc. 2: 76. 1797.

*Otidea aurantia* Massee, Fungus Fl. 4: 448. 1895.

?*Aleuria wisconsinensis* Rehm, Ann. Myc. 2: 34. 1904.

Plants gregarious or cespitose, at first globose, opening with a circular aperture and gradually expanding, at maturity varying in size from a few mm. to 5 or 6 cm. (rarely even larger), shallow cup-shaped and usually regular in form when young becoming irregular and often variously contorted with age, often from mutual pressure, rarely one sided and *Otidea*-like, occasionally discoid with the hymenium almost plane, bright-orange within, color fading in dried specimens, externally whitish-pruinose; asci cylindric or subcylindric, 12-15  $\mu$  in diameter and 175-250  $\mu$  long; spores 1-seriate, usually obliquely arranged in the ascus with the ends often overlapping, at first smooth and usually containing two (rarely more) large oil-drops, at maturity rough, roughenings taking the form of reticulations which are shallow and usually with one, rarely two, prominent projections at either end, 18-22  $\times$  9-10  $\mu$  when mature, a little smaller when young; paraphyses strongly and rather abruptly enlarged above, often with the ends subglobose, reaching a diameter of 7 or 8  $\mu$ , filled with orange granules.

On naked soil in woods or open places, often on clayey soil.

TYPE LOCALITY: Europe.

DISTRIBUTION: Newfoundland to Washington, California and West Virginia; also in Europe.

ILLUSTRATIONS: Bolton, Fungi Halifax, *pl.* 100; Bull. Herb. Fr. *pl.* 474; Bull. Lab. Nat. Hist. State Univ. Iowa, **6**: *pl.* 17, *f.* 1; Cooke, Mycogr. *pl.* 52, *f.* 203; Fl. Danici *pl.* 157; Schaeff. Fung. Bavar. *pl.* 148; Sow. Engl. Fungi *pl.* 78; Boud. Ic. Myc. *pl.* 313.

EXSICCATI: Ellis, N. Am. Fungi 836; Ellis & Ev. Fungi Columb. 15.

ALEURIA RHENANA Fuckel, Symb. Myc. 325. 1869

?*Peziza radiculata* Sow. Engl. Fungi *pl.* 114 (with descr.) 1797.

*Peziza splendens* Quél. Champ. Jura 388. 1872.

*Sarcoscypha rhenana* Sacc. Syll. Fung. **8**: 157. 1889.

?*Sarcoscypha radiculata* Sacc. Syll. Fung. **8**: 156. 1889.

Plants gregarious or cespitose, stipitate with the stems variable in length but reaching 1 or 2 cm., irregular, tomentose and attached by a dense growth of white mycelium which penetrates into the substratum binding together the leaves, twigs and leaf-mould in which they grow, the stems themselves often clinging together in clusters, abruptly expanding above into the cup which reaches a diameter of 1 or 2 cm. and about half as deep, exterior of the cup and stem white or whitish, the cups pruinose or sub-tomentose with poorly developed hair-like structures, hymenium bright-orange, color fading in dried specimens; asci cylindric above, tapering below, reaching a length of 300-350  $\mu$  and 15-17  $\mu$  thick, often becoming strongly spirally twisted at least in dried specimens; spores 1-seriate, obliquely arranged and often with the ends slightly overlapping, ellipsoid, at first smooth and with usually two large oil-drops, becoming rough, roughenings taking the form of reticulations with the meshes of the reticulations about 3  $\mu$  in diameter, rarely 5 or 6  $\mu$ , ridges extending 1-2  $\mu$  beyond the periphery of the spore, entire spore 23-27  $\times$  12-16  $\mu$ ; paraphyses enlarged above, about 6  $\mu$  in diameter, filled with orange granules.

On the ground in coniferous woods.

TYPE LOCALITY: Europe.

DISTRIBUTION: Pennsylvania to Alabama and west to Washington.

ILLUSTRATIONS: Boud. Ic. Myc. *pl.* 314; Cooke Mycogr. *pl.* 112, *f.* 400.

ALEURIA RUTILANS (Fries) Gill. Champ. Fr. Discom. 53. 1879

*Peziza rutilans* Fries, Syst. Myc. 2: 68. 1822.

*Leucoloma rutilans* Fuckel, Symb. Myc. 318. 1869.

*Humaria rutilans* Sacc. Syll. Fung. 8: 133.

*Sarcoscypha albobillosa* Rehm, Ann. Myc. 2: 33. 1904.

Plants gregarious or scattered, stipitate with the stem short, about 2 mm. thick and gradually expanding above into the cup and reaching a maximum length of about 5 mm., cup at first closed and of about the same diameter as the stem, gradually expanding and becoming turbinate with the margin more or less crenate and fringed, hymenium bright-orange, externally paler and tomentose, or with a few pale hairs about the margin of the cup, reaching a diameter of 1 cm. or occasionally larger; asci cylindric or subcylindric, gradually tapering below into a stem-like base,  $300-350 \times 20 \mu$ ; spores usually 1-seriate, obliquely arranged in the ascus with the ends overlapping, containing usually one or more, rarely two, large oil-drops and often several smaller ones, at maturity delicately reticulated, reticulations sometimes indistinct and broken, ellipsoid with the ends somewhat narrowed,  $20-25 \times 12-14 \mu$ ; paraphyses slightly enlarged above and densely filled with oil-drops and granules, about  $4 \mu$  in diameter at their apices.

On soil among mosses (especially *Polytrichum*), apparently growing on the dead leaves and often hidden by the living plants.

TYPE LOCALITY: Europe.

DISTRIBUTION: New Hampshire and New York to Iowa; also in Europe.

ILLUSTRATIONS: Boud. Ic. Myc. pl. 315; Grevillea 22: 108, f. 1-6; Bull. Lab. Nat. Hist. State Univ. Iowa 6: pl. 17, f. 2.

ALEURIA BICUCULLATA Boud. Bull. Bot. Soc. Fr. 28: 93. 1881

*Peziza bicucullata* Boud. Bull. Soc. Myc. Fr. 1: 103. 1885.

*Humaria bicucullata* Quél. Ench. Fung. 288. 1886.

Plants gregarious or crowded, at first subglobose, expanding and at maturity subdiscoïd or often irregular from mutual pressure, 5 mm. to 1 cm. in diameter, at maturity pale-orange, externally a little paler and minutely roughened; asci cylindric above, reaching a diameter of  $12-15 \mu$ ; spores obliquely 1-seriate and closely pressed together and showing a ring-like or hood-like process at either end on being separated, smooth and containing one or two oil-drops, at maturity strongly roughened, roughen-

ings taking the form of irregular and often broken reticulations, ridges of reticulations conspicuous and giving rise to rather sharp-pointed spine-like projections, terminal projections larger and giving the spore an apiculate appearance, entire spore  $20-23 \times 10-12 \mu$  (including roughenings); paraphyses rather strongly enlarged above where they reach a diameter of about  $5 \mu$ .

On bare ground or among mosses.

TYPE LOCALITY: France.

DISTRIBUTION: Wisconsin; also in Europe.

ILLUSTRATIONS: Bull. Soc. Bot. Fr. 28: pl. 3, f. 3; Boud. Ic. Myc. pl. 318.

**Aleurina** (Sacc.) Seaver, gen. nov.

*Phaeopezia* § *Aleurina* Sacc. Syll. Fung. 8: 472. 1889.

Plants medium sized, cup-shaped, fleshy or subfleshy dark-colored; asci 8-spored; spores ellipsoid, at first hyaline, becoming smoky-brown, rough, roughenings often taking the form of indistinct reticulations; paraphyses stout.

Type species, *Peziza retiderma* Cooke.

**Aleurina retiderma** (Cooke)

*Peziza retiderma* Cooke, Mycographia 176. (1877.)

*Phaeopezia retiderma* Sacc. Syll. Fung. 8: 472. 1889.

Plants gregarious or occasionally caespitose, rather deep cup-shaped, regular in form or becoming irregularly contorted, irregularity often resulting from mutual pressure, at first brown and lighter externally, hymenium soon becoming darker and at maturity almost black, exterior also becoming darker but remaining lighter than the hymenium, reaching a diameter of 2-5 cm. at maturity; asci cylindric above, rather abruptly tapering below into a stem-like base, reaching a length of  $275 \mu$  and a diameter of  $12-14 \mu$ ; spores 1-seriate, ellipsoid, at first hyaline, smooth and containing one or two oil-drops, gradually becoming roughened, smoky-brown, roughenings usually giving rise to one large protuberance at either end of the spore and irregular reticulate markings over the surface of the spore, the reticulate ridges so arranged as to give the spore a somewhat striate appearance, entire spore at maturity  $15-17 \times 10 \mu$ ; paraphyses strongly enlarged above, where they reach a diameter of  $8 \mu$ , minutely granular within and dilutely colored.

On the ground in woods often among mosses.

TYPE LOCALITY: Portland, Maine.

DISTRIBUTION: New York to Maine and Wisconsin.

ILLUSTRATION: Cooke, Mycographia, *pl.* 79, *f.* 306.

***Aleurina aquehongensis* sp. nov.**

Plants gregarious or scattered, sessile, discoid to shallow cup-shaped, reaching a diameter of about 1 cm., externally slightly roughened, entirely brownish-black, with a slightly greenish tint to the hymenium which appears to be due to the spores which have dusted out of the asci; asci cylindric above, tapering below into a rather irregular stem-like base, reaching a length of 300–350  $\mu$  and a diameter of 15–17  $\mu$ ; spores 1-seriate or occasionally slightly crowded, ellipsoid to subfusoid with the ends narrowed and containing one or two oil-drops, at first smooth, becoming rough, roughenings taking the form of irregular reticulations, mature spore  $22\text{--}25 \times 10\text{--}12 \mu$ , hyaline, becoming pale smoky-brown, color more or less evanescent; paraphyses rather strongly enlarged above, reaching a diameter of 6  $\mu$ , pale-brown.

On the ground in a damp place.

Type collected by N. L. Britton and F. J. Seaver near Oakwood Heights, Staten Island, September 5, 1914.

DISTRIBUTION: Known only from the type locality.

EXPLANATION OF PLATES CXLII–CXLIV

PLATE CXLII

Upper figure, *Aleuria rutilans* (Fries) Gill. Photographed from material collected at Hudson Falls, New York, by Mr. Stewart H. Burnham.

Lower figures, *Aleuria rhenana* Fuckel. Photographed from material collected at Mill City, Oregon, by Dr. W. A. Murrill.

PLATE CXLIII

Upper figure, *Aleuria aurantia* (Pers.) Fuckel. Photographed from material collected in the New York Botanical Garden, by the writer.

Lower figure, *Aleurina retiderma* (Cooke) Seaver. Photographed from material collected at Portland, Connecticut, by the writer.

PLATE CXLIV

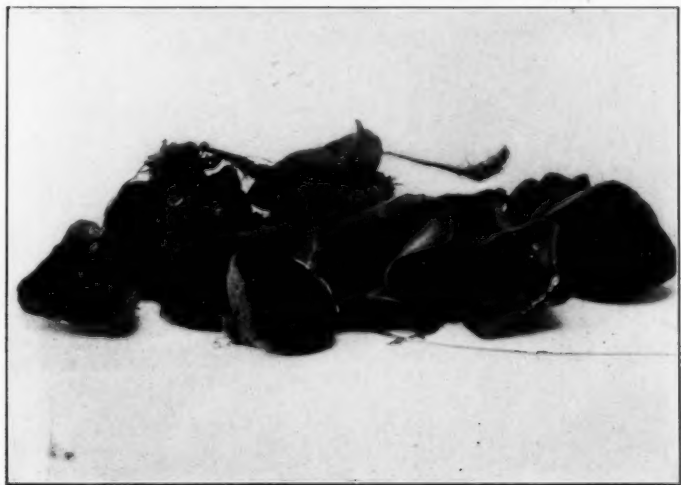
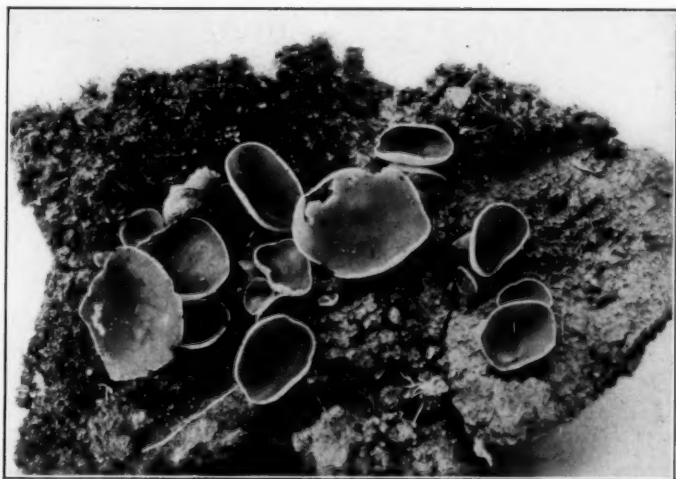
Spores and paraphyses drawn with the aid of the camera lucida to a common scale. Where the base of the ascus is shown, it is doubled back to save space.

1. *Aleuria aurantia* (Pers.) Fuckel.
2. *Aleuria rhenana* Fuckel. This drawing shows the spirally coiled base of the ascus as it often occurs in this species.
3. *Aleuria bicucullata* Boud.
4. *Aleuria rutilans* (Fries) Gill.
5. *Aleurina aquehongensis* Seaver.
6. *Aleurina retiderma* (Cooke) Sacc.

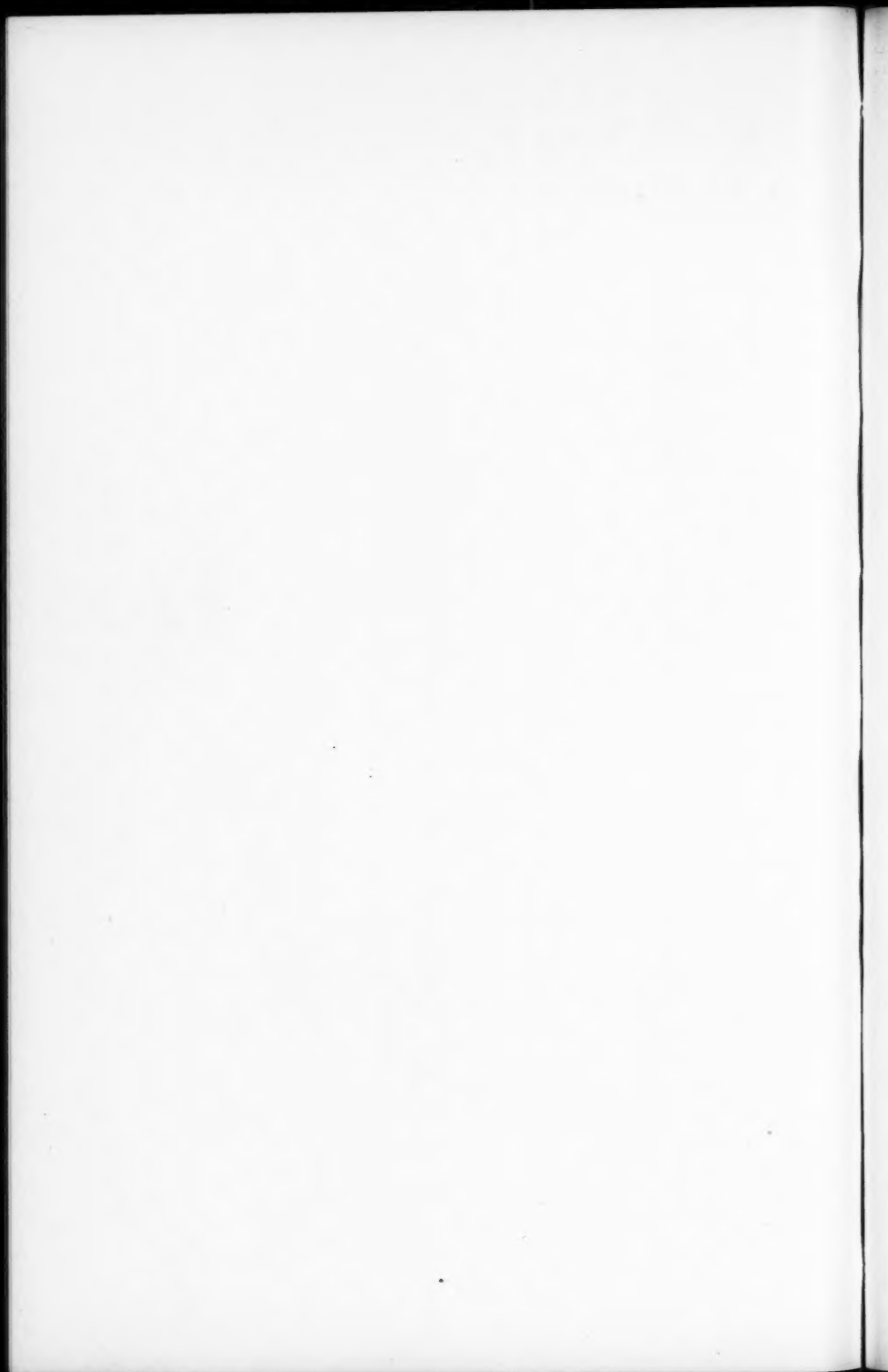


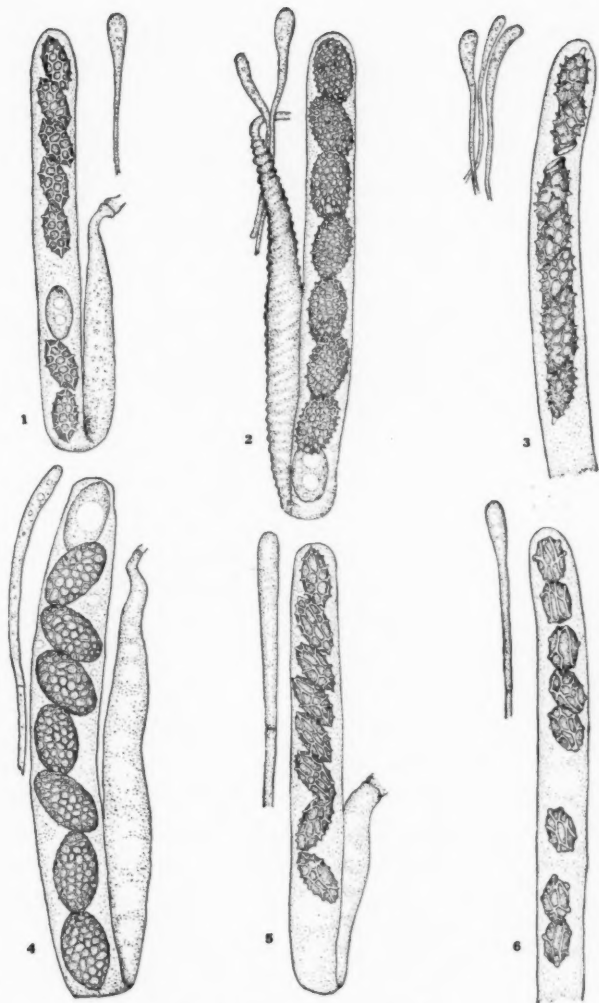
ALEURIA RUTILANS (FRIES) GILL.  
ALEURIA RHENANA FÜCKEL



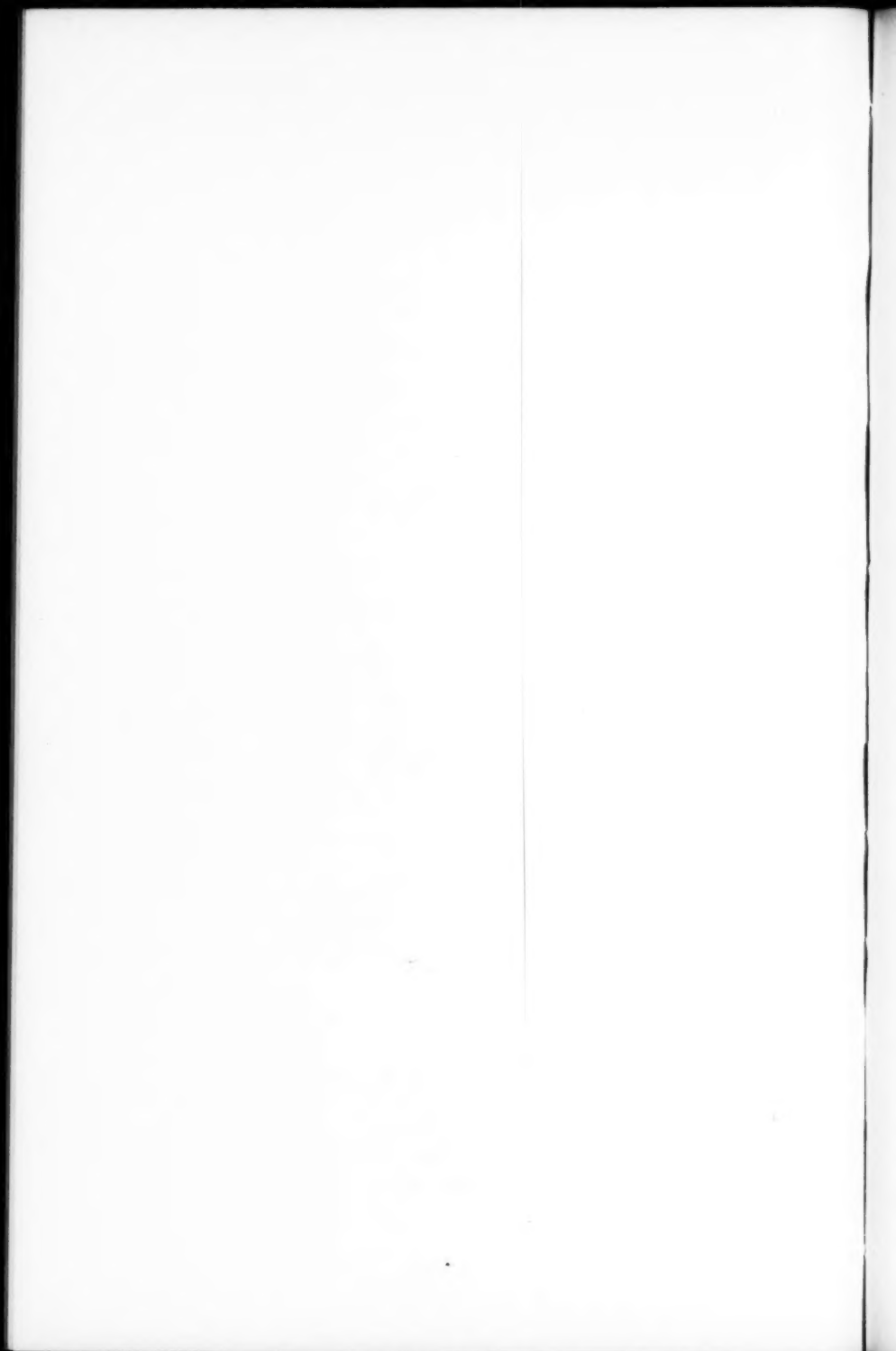


ALEURIA AURANTIA (PERS.) FUCKEL  
ALEURINA RETIDERMA (COOKE) SEEVER





ALEURIA AND ALEURINA



## PARASITISM IN HYMENOCHAETE AGGLUTINANS

ARTHUR H. GRAVES

(WITH PLATE 145, CONTAINING 5 FIGURES)

Probably every one in the eastern United States who is interested in the fungi knows *Hymenochaete agglutinans* Ellis, at least by sight. The writer had been acquainted with it for many years before he knew its name, but, when its identity was once revealed, the aptness of its name made it unforgettable.

During the month of July, 1914, cases of disease directly due to the action of this fungus were observed, and the results of the investigation of these cases form the subject of the present paper.

While carrying on some experimental work in the woods at Mt. Carmel, Connecticut, the writer's attention was attracted by a small bush or tree which appeared to have been suddenly killed. The leaves, although still a dark-green, were withered and dry, and hung downward, presenting a sharp contrast to the surrounding healthy foliage. Thus, from a little distance, the symptoms were those of a sudden girdling of the plant, as, for example, from the work of an insect, or possibly as a result of mechanical injury. (Plate 145, figure 1.)

On examination, the plant was found to be a large spice bush [*Benzoin aestivale* (L.) Nees], with several main stems. One of these, the diseased shoot in question, was firmly bound to a dead trunk of alder [*Alnus incana* (L.) Moench.], which lay in an approximately horizontal position. The binding material was furnished by the fungus, *Hymenochaete agglutinans*, which, with the dead alder trunk as its source, had completely surrounded the spice bush stem and cemented it closely to the alder. Above this point of contact, with the exception of one short branch, the spice bush was entirely dead. (Plate 145, figures 1 and 4.) Further inspection revealed a young red maple (*Acer rubrum* L.) attached to the same dead alder in a similar manner, and also killed above the

point of contact. In the immediate vicinity, two branches of apple (*Pyrus Malus* L.) which had also come in contact with infected alders, had been killed in the same way.

That, in the case of the diseased spice bush, the dead alder was the source of infection, was proven by the fact that at many points along the alder trunk the fruiting bodies of the fungus appeared, in these cases being simply flat, more or less circular, blackish crusts. Moreover, where the trunk emerged from the soil, it was fairly covered with a crust of the same fungus, which was good evidence, when the parasitic tendencies of the fungus were definitely ascertained, that the alder had itself died from the attacks of the *Hymenochaete* at its base. The wood of the alder was quite soft, and evidently contained the mycelium of the *Hymenochaete* in great abundance.

As already stated, a casual glance might have inclined one to the belief that death in the case of the Benzoin had been sudden, but a more careful study of the parts above the girdled portion, and also of the fungus itself, proved that this was not the case.

First, a study of the growth in length of the various shoots above the infection showed conclusively that this part of the plant had been laboring under some difficulty for a considerable period. This may be seen from the following table:

TABLE I  
COMPARATIVE LENGTH OF ANNUAL GROWTHS ON DISEASED PORTION

1912	1913	1914
8¾ inches	6 inches	2½ inches
10 "	6 "	3 "
9 "	4½ "	2½ "
9 "	11 "	5¾ "
7½ "	4 "	1¾ "
8¾ "	6¾ "	1¾ "

The shoots selected for these measurements represented the principal growths in length of this part of the plant, and in every instance but one they show a continually decreasing growth in length until death occurred in 1914. The growth of each shoot during 1914 was remarkably slight as compared with the normal growth of 1912, and the growth of 1913, except in one instance, shows a marked decrease.

On the other hand, a branch originating just below the earlier parts of the infection (Plate 145, fig. 4) showed corresponding increases in the growth in length of its main shoots, as may be seen from table II.

TABLE II

COMPARATIVE LENGTH OF ANNUAL GROWTHS OF BRANCH BELOW GIRDLED PORTION<sup>1</sup>

1912	1913	1914
2¼ inches	2½ inches	9 inches
	¾ inch	1½ "
	¾ "	1¾ "
1¾ "	1¾ inches	3½ "

Again, examination of the fungus at the point of contact of the two plants showed periods of growth which could be correlated pretty well with the facts just mentioned. Apparently three years of growth were present, each one marked by a different color in the fungus. The growth of the first year, i. e., 1912, was black, that of 1913 a grayish hue, while the recent growth of 1914 was colored a creamy-yellow in the outer portions, shading into a deep rich-brown toward the inner parts. (Plate 145, figures 2 and 5.)

On the evidence presented by these observations, therefore, the girdling from the fungus first commenced in 1912. In the following year the effect of this girdling began to show itself in a marked decrease in the vigor of the year's shoots, a result which was enhanced by the continued development of the fungus. In 1914 the action of the fungus had progressed so far that the plant could make only a feeble growth, which soon died when all communication with the lower parts of the stem was shut off.

Microscopic examination showed clearly the presence of numerous hyphae among the living cells of the stem. For this study, sections were cut through the lower part of the region attacked, where it was partially overgrown with the fungus. (Plate 145, figures 2 and 5.) At this point, as would be expected, much of the stem was still alive. Yet the cambial region in many places had taken on a brownish color, and here, as well as in the living medullary ray cells of the wood, the presence of mycelium could be clearly demonstrated. A common mode of entrance of the

<sup>1</sup> As shown in Plate 145, Fig. 2, this branch had already, in 1914, become invested with the fungus and probably would have succumbed in its turn.

fungus into the stem was by way of the lenticels, and wedges of mycelium, using this means of ingress, could be easily made out in the bark.

It should also be mentioned that the piece from which the sections were cut was left with its lower end in water, and in a little more than a day a vigorous growth of mycelium had developed from the cut surface on the diseased portions. (Plate 145, fig. 3.)

There is therefore no doubt that *Hymenochaete agglutinans* is a facultative parasite. Yet the question at once arises, Why should it require two years to kill a small branch like that described above? In this connection we might recall the action of *Thelephora laciniata* Pers.,<sup>2</sup> a fairly close relative of *Hymenochaete*. For some time this fungus has been known to kill young plants by enveloping them with its mycelium and practically smothering them to death. It would appear that in the present case also a similar although more local effect of the fungus obtains. The close band of the fungus surrounding the stem becomes tighter and tighter as the stem grows in diameter, similar to the condition so familiar in the case of a vine twining around a stem. Moreover, as the fungus increases the area of its operations, the original band becomes hard and dry. It is significant also that the region where the fungus first encircled the stem is actually smaller in diameter than the part above. (Plate 145, fig. 5.) That this is not due to a thicker growth of the hymenium above, was proved by cross sections.

Such a condition, then, would produce a genuine girdling effect, resulting in weaker and weaker growth of the parts above, but increased growth of the parts below. Possibly not until the stem is thus weakened does the fungus commence its parasitism upon the tissues.

It might be argued that parasitism of the fungus alone could produce these symptoms, as indeed really happens in the chestnut bark disease. But if this were the case, death should ensue as soon as the stem is once girdled by the fungus, or very soon after. There is every indication, therefore, that here the parasitism of the fungus is supplemented by a mechanical, choking action.

<sup>2</sup> Hartig, R. Der zerschlitze Warzenpilz, *Thelephora laciniata* Pers., Untersuchungen aus d. forstbot. Inst. 1880.

*Hymenochaete agglutinans* was described in 1874 by Ellis<sup>3</sup> as follows: "Of rather loose texture and of a light yellow color at first, becoming firmer and of a light tan color or rufous tint as the bristles are developed; closely adnate with a determinate margin, which is tomentose at first; forming orbicular or elongated patches or sometimes entirely surrounding the twig or limb on which it grows for an inch in length.<sup>4</sup> Common in autumn in swampy thickets on *Andromeda*, *Vaccinium*, etc., without much discrimination, fastening the stems or branches together wherever a dead twig or branch lies in contact with a living one: turns black and dries up during the winter."

Peck,<sup>5</sup> a few years later, reported the same species "on trunks and branches of living alder trees. Sandlake, and Adirondack Mountains." (New York.)

Saccardo,<sup>6</sup> in 1888, recorded the species, stating that it was indigenous to North America, and citing the collections of Ellis and Peck.

Later, Massee<sup>7</sup> included the species as indigenous to the United States in his monograph on the Thelephoreae, remarking as follows: "A well marked species, and certainly a genuine *Hymenochaete*. . . . Often completely surrounding twigs or cementing two together by growing continuously around both. Hymenium pale but often bright yellow, with ferruginous shades due to the setae."

We find the same species also recorded by Longyear<sup>8</sup> as common on oak limbs in Michigan.

A careful search through the literature has failed to disclose any definite record of parasitism in this species. Ellis' description, of course, points to such a relation where he speaks of fastening a dead twig or branch to a living one, and Peck also notes

<sup>3</sup> Ellis, J. B. New species of fungi found at Newfield, New Jersey. Bull. Torrey Club 5: 45-46. 1874.

<sup>4</sup> The specimen on Benzoin measured about four and one half inches in length.

<sup>5</sup> Peck, C. H. Ann. Rep. N. Y. State Mus. 30: 47. 1878.

<sup>6</sup> Saccardo, P. A. Syll. Fung. 6: 602. 1888.

<sup>7</sup> Massee, George. A monograph of the Thelephoreae. Part II. Jour. Linn. Soc. 27: 95-205, pl. 5-7. 1891.

<sup>8</sup> Longyear, R. O. A preliminary list of the saprophytic fleshy fungi known to occur in Michigan. Rep. Mich. Acad. Sci. 4: 113-124. 1904.

it on living alder trees. Yet the statement that it actually kills the living branches is lacking.

A point of interest and practical importance is the fact that the fungus is apparently not particular as regards the selection of its hosts. We find that another species, *H. noxia*, exhibits this same characteristic. This species, common in tropical regions, has recently attracted considerable attention as an active parasite on tea, cacao, cotton, rubber, breadfruit, camphor, etc.<sup>9</sup>

Although we do not believe the disease caused by *Hymenochaete agglutinans* is at present of any economic importance, still it is conceivable that under certain conditions it might be capable of causing appreciable damage, as when plantations of young trees in moist localities are in close proximity to infected trees and shrubs, such as alder, *Vaccinium*, etc. Under such circumstances it would of course be advisable to cut out and burn the infected plants. Such work would entail the expenditure of only a few moments' time, and would probably save valuable trees from infection.

#### EXPLANATION OF PLATE CXLV

FIG. 1. Photograph showing diseased *Bensoia aestivale* in its natural environment. Dead horizontal trunk of alder in the foreground, the point of contact of spice bush and dead alder a little below the center of the picture. Above this point, the withered, dead portion; and a little to the right, vigorous young shoots which have developed from the base of the plant.

FIG. 2. Photograph showing *Hymenochaete agglutinans* originating in the dead alder trunk, and surrounding the stem of the spice bush. The annual growths of the fungus, or rather, the hymenium, are shown; the first, a semi-circular patch to the left of the spice bush, and surrounding it; the second, extending nearly to the lateral branches above and below the point of contact, and the third, of a lighter color, to points beyond the branches.  $\times \frac{1}{8}$ .

FIG. 3. Photomicrograph of spice bush stem cut transversely a little below the insertion of the lower lateral branch in Fig. 2. Showing mycelium on the cut surface, grown out after the piece had been left with its other end in water for about two days. The fungus is especially active in the bark, the region of the cambium being shown by the dotted line.  $\times 5$ .

FIG. 4. Photograph of diseased spice bush and part of alder trunk brought into the laboratory. The healthy green leaves wilted during transportation.

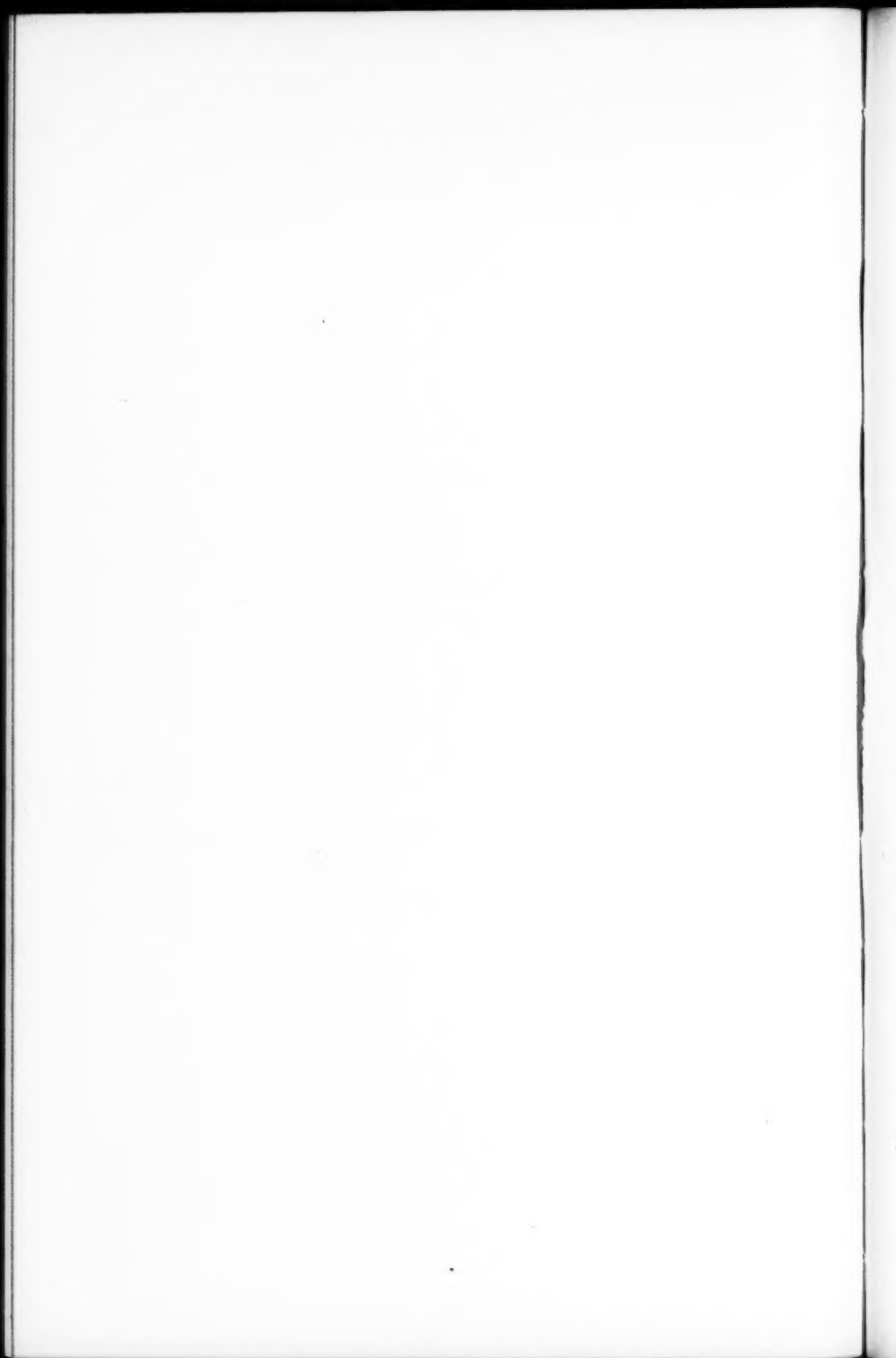
FIG. 5. Same as figure 2, enlarged.  $\times 2/5$ .

OSBORN BOTANICAL LABORATORY,  
YALE UNIVERSITY,  
NEW HAVEN, CONN.

<sup>9</sup> Cook, M. T. Diseases of tropical plants. London, 1913.



HYMENOCHAETE AGGLUTINANS ELLIS



## TWO NEW SPECIES OF WATER MOLDS

(WITH PLATES 146-148, CONTAINING 38 FIGURES)

W. C. COKER

Since the publication of my third new species of *Achlya*<sup>1</sup> in 1912 a continued study of the occurrence and periodicity of the Saprolegniaceae in Chapel Hill, has discovered two other new and remarkable forms of that family.

The first of these was met with as long ago as March, 1911, and it has been found twenty-five times since. Pure cultures on various media, generally from a single spore, have been kept under observation for over three years. So puzzling is the form that after preparing a description of it in 1912 it was decided to continue collections and experiments for another year before publication. The difficulty arises from the fact that our plant combines in a most confusing manner the characters of both *Achlya* and *Saprolegnia*, and a rigid interpretation of these genera as at present defined would exclude it from both. As the formation of a new genus in such a case could not simplify matters, and as the genera *Achlya* and *Saprolegnia* are sufficiently distinct except for this narrow point of contact, it would seem much better to retain them and admit the variations. The case is not unlike the situation in the two genera *Puccinia* and *Uromyces*, where forms are known that combine the characters of both. As the proliferation of the sporangia is usually of the *Achlya* type I have decided to refer this form to the genus *Achlya* and to define it as follows:

### *Achlya paradoxa* sp. nov.

Plant delicate; hyphae straight, slender, and little branched, the larger threads having a diameter of about 37  $\mu$ ; many much smaller, the average being about 10-15  $\mu$ ; sporangia plentiful at all stages, narrowly club-shaped and largest at the distal end which is about 55  $\mu$  in diameter, rounded, and furnished with a distinct but short papilla; secondary sporangia formed usually

<sup>1</sup> MYCOLOGIA 4: 325. 1912.

by cymose branching beneath the old ones, but occasionally also by proliferation through the empty ones, exactly as in *Saprolegnia*. Spores formed in several rows as in *Saprolegnia* and *Achlya*, on emerging all ciliated, but varying greatly in behavior—some swimming away as a rule, others remaining attached to the tip of the sporangium; oogonia produced on the tips of short lateral branches, usually near the base of the main hyphae, sometimes intercalary; their walls smooth and without pits, except for the thin places where the antheridia are attached; oospores usually two, often four and rarely one or eight; their diameter from 22 to 37  $\mu$ , averaging about 30  $\mu$ ; antheridia always present, generally several on each oogonium, short club-shaped and terminating slender branches of declinuous origin which show a decided tendency to twine about the oogonial branches; antheridial tubes enter the oogonia, run among the eggs, and probably fertilize them.

In fig. 1 the sporangia are shown in a group after the manner of *Achlya*. The bending of the sporangia that is quite noticeable in this figure is characteristic, though not always so pronounced.

In figs. 2 and 3 are shown the proliferation of sporangia by both the *Achlya* and *Saprolegnia* methods on the same thread. The latter method is rare, but when it does occur is exactly as in *Saprolegnia* a condition that has not been observed in any other species of *Achlya*. In fact I know of no reference in the literature to internal proliferation of any kind in *Achlya* except by Peterson<sup>2</sup> who says: "Thus I have seen zoosporangia which had proliferated in undoubted species of *Achlya*."<sup>3</sup> The behavior of the spores on emerging is remarkable and very variable. In regard to their action I shall give the following quotation from my notes made at the moment of observation:

The spores emerge somewhat elongated and may be seen to bend backward at the ends and fuse into a pear-shaped spore, as is the case in *Leptolegnia*. The spores are very sluggish and most of them fall down immediately around the sporangium mouth and encyst, also a lot are often left in a group that sticks to the sporangium mouth, giving the effect of *Achlya*.

I find cases where all, or nearly all, of the spores group themselves at the mouth exactly as is typical for *Achlya*. When conditions are unfavorable the spores sometimes do not emerge at all and in such cases they sprout in position.

Noticed two sporangia empty near together. In one the spores grouped themselves at the mouth of the sporangium just as in *Achlya*, except that a

<sup>2</sup> Ann. Mycologici 8: 520. 1910.

<sup>3</sup> The extreme rarity of such a phenomenon in *Achlya* would make it desirable that such an observation be accompanied by figures.

few of the outermost gently rocked themselves away a little distance from the main mass and then settled down. The spores that remained in a mass at the tip of the sporangium also showed a very slight rocking movement, thus proving the presence of cilia, but in a couple of minutes they became quite still. In the other sporangium the spores charged out with great rapidity and everyone dashed rapidly away.

A sporangium emptied at 11:13 and all the spores sank slowly to the bottom of the dish separating themselves considerably by a gentle rocking motion. After settling, individuals would move spasmodically at intervals, turning and jerking, but none swam actively or any distance. This interrupted movement continued for at least a half hour after emergence.

The existence of cilia thus indicated by the behavior of the spores was demonstrated by treatment with potassium iodide solution at the moment of emergence. A sporangium so treated is shown in fig. 4. All the spores can be distinctly seen to have cilia. From these observations it will be seen that the behavior of the spores in *Achlya paradoxa* has no parallel in the genus.

In figs. 5, 6, 7, 8, a series of oogonia are shown with normal variation. Oogonia without stalks and with their bases formed from a section of a hypha are not at all rare (fig. 5.) The variation in size of the oogonia is extreme. The smallest are not more than  $23\ \mu$  in diameter, the largest may reach  $74\ \mu$ .

Slender upgrowths into the oogonium from the partition below are occasionally seen. Such growths often appear in other species of *Saprolegnia* and *Achlya*, but, while they give the effect of antheridial tubes, they are usually quite functionless. The antheridia themselves are peculiar. They are sudden enlargements of the tips of the antheridial branches and are short, thick and tubercle-like. They often proliferate, and usually by growth from near the base of the antheridial cells themselves. These outgrowths are then cut off as separate antheridia (figs. 7 and 8). When first formed the antheridia are well filled with protoplasm and contrast strongly with the almost colorless branches that bear them. Later the antheridia appear almost empty as if they had discharged their contents into the eggs. This, however, was not actually observed. Chlamydospores unlike the oogonia, are not rare, but appear plentifully, though not densely, in almost all cultures. The majority terminate short branches and approximate the oogonia in size, shape and position (fig. 9): others are arranged in chains (fig. 10) which are usually curved or contorted.

Elongated and irregular forms are also produced from somewhat swollen and knotted segments of the hyphae.

Under ordinary cultural conditions such as on flies, ant larvae, gnats, mushroom grubs, etc., in water there is usually no sexual reproduction. Out of a hundred cultures perhaps one would show a few oogonia. A number of experiments have been made to induce the formation of oogonia. The results of some of these are as follows:

- On a bit of whole egg agar in distilled water: Growth vigorous and healthy. Sporangia abundant, emptying normally and proliferating laterally from below. No oogonia or chlamydospores.
- On a bit of whole egg agar in distilled water: Growth vigorous, reaching a diameter of 4 cm. Sporangia slow to form, but after full growth appearing rather plentifully. Chlamydospores of usual shape present, but not plentiful. No oogonia.
- On a bit of hard boiled egg yolk in distilled water: Growth vigorous, reaching a diameter of 4 cm. Sporangia abundant and formed earlier than in culture above. Chlamydospores plentiful. Oogonia present, but scarce. Antheridia of diclinous origin. As this was a culture from a single spore, the presence of antheridia proves that the plant is not dioecious.
- On a bit of whole egg agar in spring water: Growth vigorous and strong. Many chlamydospores. No sexual reproduction.
- On fly in spring water: Growth vigorous. Many sporangia, all proliferating from side below as in *Achlya*. No chlamydospores or oogonia.
- On corn meal agar: Growth extensive, filling dish. Aerial branches nearly reaching cover, but not dense. Only chlamydospores present.
- In 5 per cent. maltose + 0.1 per cent. peptone solutions mixed half and half: Growth vigorous and healthy. A few small sporangia were formed, but the spores were only imperfectly discharged. Also a few of the characteristic knob-like chlamydospores.
- On corn meal agar in tightly stopped sterile bottle: Growth vigorous, extending across bottle and making a mold-like aerial growth an inch high. On examination there were found only single chlamydospores, most of which were quite empty, they having sprouted by a slender thread about 3  $\mu$  in diameter. In fact all the growth was remarkably slender (3  $\mu$  in diameter), enlarging to normal size only just below the chlamydospores.
- On corn meal and egg yolk agar: Growth very strong, covering dish and developing abundant aerial hyphae that reach the cover. No reproduction of any kind.

The following six cultures were all made on ant larvae in distilled water with the salt added as indicated:

- In 0.1 per cent.  $\text{KNO}_3$ : Growth good. Normal sporangia, discharging and spores taking second swim. Many good chlamydospores of usual shape, the larger ones having a tendency to form the cross wall some way up from the base. No sexual reproduction.

- In 0.1 per cent.  $\text{KH}_2\text{PO}_4$ : Growth good. Many normal sporangia discharging, and spores taking second swim. Many chlamydospores. No sexual reproduction.
- In 0.1 per cent.  $\text{Na}_2\text{HPO}_4$ : Growth good. Many normal sporangia discharging, and spores taking second swim. A good many chlamydospores, but not so numerous as in the preceding cultures. No sexual reproduction.
- In 0.1 per cent.  $\text{K}_2\text{SO}_4$ : Growth slight. Culture infested with fungus. Sporangia formed but not discharging. A few chlamydospores. No sexual reproduction.
- In 0.1 per cent.  $\text{Ca}_3(\text{PO}_4)_2$ : Growth good. Many normal sporangia discharging, and spores taking second swim. Many chlamydospores of usual shape. No sexual reproduction.
- In 0.1 per cent.  $\text{Ca}(\text{NO}_3)_2$ : Growth good. Many normal sporangia discharging, and spores taking second swim. Many chlamydospores. No sexual reproduction.

The following seven cultures were all made on hard boiled egg yolk in distilled water with the chemical added as indicated:

- In 0.1 per cent.  $\text{KNO}_3$ : Strong growth. No sporangia. A few good chlamydospore. No sexual reproduction.
- In 0.1 per cent  $\text{KH}_2\text{PO}_4$ : Growth good. A very few sporangia with normal discharge. No chlamydospores or sexual reproduction.
- In 0.1 per cent.  $\text{Na}_2\text{HPO}_4$ : Strong growth. Abundant sporangia proliferating repeatedly, and discharging normally. A very few chlamydospores. No sexual reproduction.
- In 0.1 per cent.  $\text{K}_2\text{SO}_4$ : Strong growth. Sporangia plentiful. Chlamydospores abundant. No sexual reproduction. One sporangia was seen discharging. The emergence was rather slow, and the last few spores were very slow and showed obvious swimming movements in the sporangium on escaping. About a dozen clung to the tip of the sporangium. The others spread in a loose flock, showing slow movements, and every now and then one would swim briskly away.
- In 0.1 per cent.  $\text{Ca}_3(\text{PO}_4)_2$ : Strong growth. Many sporangia, quite normal. A very few chlamydospores. No sexual reproduction. Several sporangia seen to discharge. Six spores detached themselves at different points and moved away, soon stopped and settled to the bottom. All others remained attached in a pretty solid mass to the tip of the sporangium. In another case four were detached. In another case six were detached.
- In 0.1 per cent  $\text{Ca}(\text{NO}_3)_2$ : Very little growth. A good many chlamydospores. Nothing else.
- In 0.1 per cent.  $\text{K}_2\text{PO}_4$ : Strong growth. Abundant sporangia. Many good chlamydospores that look exactly like oogonia initials, and a good many smaller branches that suggest antheridial branches, but no oogonia.

The genus *Pythiopsis* has until now included but one species, *P. cymosa*, discovered in Germany by De Bary.<sup>4</sup> It has been recognized only one since, it seems, when Humphrey<sup>5</sup> found it

<sup>4</sup> Bot. Zeit. 46: 63. 1888.

<sup>5</sup> The Saprolegniaceae of the United States. Transactions Amer. Philos. Soc. 17: part 3.

at Amherst, Mass. From two figures given by Hine<sup>6</sup> I am inclined to think that he had before him the sporangia of this plant, but that was before it had been described, and he did not get any further with it. I have found this species a good many times in Chapel Hill in springs, brooks and marshes; for example, in Terra Cotta Spring, Glen Burnie Farm (Jan. 15, 1913), twice in a marshy place near the above spring (once on Jan. 15 and again on Jan. 30, 1913), in Howell's Spring (Jan. 7, 1914), in Howell's spring and the brook below (March 3, 1914), etc. As the plant has so far been rather inadequately figured and described I shall give a short account of it before describing the new species. The sporangia, oogonia and antheridia are well shown by De Bary and Humphrey, but variations occur that were not observed by them. The antheridial cells, as formed in about one half the oogonia are unique in position. They arise by the enlargement of the hypha immediately below the oogonium and the growth of this segment along the base of the oogonium for a short distance. A tube is formed near the septum and enters to the egg. As the antheridial cell is in close contact with the oogonial wall from the septum out, the position of the septum becomes obscured and the oogonium seems to be seated at maturity on a large, swollen, basal cell. Under high power, however, the original septum may be seen as a somewhat thicker disc. This form of antheridium, as shown in fig. 1 and in one of the two in fig. 2, is not exactly illustrated in either De Bary's or Humphrey's figures. From this strictly basal and closely pressed antheridium we have in the remaining half of the oogonia all sorts of variations. The antheridium may be elevated on a stalk that varies from nothing to half the length of the oogonium and in very rare cases the antheridium may be even of declinous origin (figs. 5 and 6). The appearance of several antheridia on one oogonium is of rather frequent occurrence in my cultures. This is not recorded by De Bary or Humphrey. From figures 3 to 7 an idea may be gained of the variations observable in both antheridia and oogonia. De Bary does not give the size of the oospores. I find them to vary from 16.5 to 24  $\mu$ , with an average of about 19.5  $\mu$ . This is a little larger than the figures given by Humphrey.

<sup>6</sup> Figs. 6 and 7, plate 5, Amer. Micr. Journal 1. 1878.

The remarkable intercalary oogonium shown in fig. 8 is unique. Its single egg was  $27.8$  by  $50\ \mu$  in size and a large number of oil-drops were grouped at each end. An antheridial cell was also cut off at each end, but no antheridium could be made out.

The peculiar jelly-like outer layer that De Bary noticed on the oogonia in October cultures was also seen by Humphrey in a few cases. By careful observation I have been able to make out this layer in the majority of young oogonia. It is probably present on all at a certain stage, but in clean cultures free from bacteria is very hard to trace. Its presence and outline is hardly discernable, except for the bacteria and other minute particles that stick to it. As remarked by Humphrey it is hardly possible that this hyalin gelatinous outer sheath can be a "periplasm" secreted from the oogonium contents, as De Bary suggests. It is more apt to be due to the gelatinization of a thin outer layer of the wall of the oogonium.

In a typical clean culture in springwater on a mushroom grub the sporangia varied from  $37$  to  $56\ \mu$  in diameter, the majority being from  $44$  to  $48\ \mu$  broad.

In figures 9 and 10 are shown sporangia of usual appearance. When the sporangia proceed at once to the formation of spores the discharge is usually at the tip (fig. 9). If a rest occurs, the immergence tube is as apt to appear at the base, as shown in fig. 11. After the first sudden release of pressure the spores do not rush out as in *Achlya* and *Saprolegnia*, but emerge much more quietly as they find the opening. The last ones often swim around a long time in the sporangium before finding an exit. The spores are pear-shaped, with two cilia at the small end. On coming to rest they round up. In fig. 12 are shown three normal spores and an anomalous double one with four cilia. This is not a case of fusion after emergence, but of imperfect segmentation of the protoplasm. I have often seen in species of *Achlya* the discharge of large lumps and irregular masses of protoplasm from the sporangia as a result of imperfect segmentation. Sometimes the whole mass may in *Achlya* be thus discharged as a single long, contorted rope (see below p. 300). Leitgeb<sup>7</sup> shows similar masses of protoplasm in *Saprolegnia monoica* (under the name of *Diplanes*).

<sup>7</sup> Jahrb. für Wiss. Bot. 7: 357, plate 24, figs. 3-5. 1869.

Resting bodies of more or less globular shape are formed in quantity and are often arranged in chains (fig. 11). After a rest these also form zoospores.

Our new species of *Pythiopsis* has appeared eight times in collections made in the neighborhood of Chapel Hill. It was first obtained on Feb. 29th, 1912, from collections made at intervals along the brook that flows from the spring about 100 yards to the northwest of Dr. Archibald Henderson's residence. A tumbler of water was taken at each place with a little mud and any algae and dead leaves, twigs, etc., that happened to be present. Ant larvae were floated on the surface of the water of each tumbler and in four of these appeared a species of *Pythiopsis* that was found to be new. It was also found on the same day in a springy marsh on the south side of Glen Burnie Meadow and appeared subsequently in the brook in Battle's Park (March 18, 1912), in the branch south of the South Building, U. N. C. (March 25, 1912), and again in the Glen Burnie Meadow Marsh (May 13, 1912). The plant was separated from other fungi present and was grown in pure cultures for about six months. I have named the species in honor of the late Dr. James Ellis Humphrey, author of "*The Saprolegniaceae of the United States*," whose work has been of great assistance to all students of this group in America. The species may be defined as follows:

***Pythiopsis Humphreyana* sp. nov.**

Vegetative growth of long, slender, sparingly branched hyphae of about 11 to 14  $\mu$  in diameter throughout, stouter in the neighborhood of the reproductive bodies, after maturity disorganizing rather quickly; sporangia varying in shape from spherical, oval or pyriform to elongated, tapering and irregular forms, discharging by a short or rather long papilla and usually proliferating from below in a cymose manner; spores monoplanetic, pear-shaped and with two cilia, about 8.9  $\mu$  in diameter on coming to rest; oogonia generally borne exactly like the sporangia and not to be distinguished from these when young, apical and often in groups by cymose branching, usually spherical with a basal neck, sometimes pear-shaped and rarely longer and more irregular, varying greatly in size, diameter from 33 to 89  $\mu$ , averaging about 43  $\mu$ ; wall always smooth and unpitted, about 1.4  $\mu$  thick; oospores generally one, occasionally two and very rarely four, centric,

diameter from 24 to 40  $\mu$  averaging about 30  $\mu$ , the wall about 2  $\mu$  thick, not so nearly filling the oogonium as in *P. cymosa*; antheridia short-clavate, terminating a stalk that usually arises from immediately below the oogonium, but sometimes of more distant origin, or rarely declinuous, one, two or occasionally more on every oogonium and generally applied to its top or distal half, with an antheridial tube which reaches and apparently fertilizes the egg; resting bodies resembling sporangia or oogonia present in quantity, after a rest forming spores or germinating with tubes.

The species is sharply separated from *P. cymosa* by the much larger and always smooth oogonia, larger eggs, larger sporangia, absence of strictly basal antheridia and presence of elongated forms of sporangia. Illustrations of the globular type of sporangia, which are the first to appear in clean and vigorous cultures are given in figures 1 and 2. They are of the same appearance as those of *P. cymosa*. The papilla is usually formed at the tip when growth is active, but if there is a rest it is as apt to be formed at any other point (figs. 2, 7, 10). Intermediate and elongated forms are shown in figs. 4 to 10. As in *P. cymosa* the internal pressure is dissipated before the last spores emerge and it is often many minutes before all find the exit. As shown in the figures, the papilla may be quite abrupt or may gradually taper into the body of the sporangium.

The oogonia are often closely associated with the sporangia (figs. 2, 11 and 12), but the more common arrangement is a terminal oogonium on a rather short lateral branch as shown in fig. 13, with a single stalked antheridium arising from immediately below it. The antheridial branch almost invariably carries but a single antheridium, which is short, thick and densely filled with protoplasm. The antheridial tube is quite conspicuous and its behavior is such that there is scarcely any doubt that fertilization takes place. The protoplasm of the antheridium passes into the tube and soon after no protoplasm or tube can be seen, indicating the discharge of the former and collapse of the very thin-walled tube. The tubes are distinctly shown in figs. 11, 12 and 15.

Oogonia with two eggs are not very rare. One of these with two antheridia is shown in fig. 14. Oogonia with four eggs were seen twice. One of these, of anomalous shape, is shown in fig. 16. The occurrence of more than one egg in the oogonium of *P.*

*cymosa* is quite rare. Humphrey saw two eggs only once and my cultures of that species have not produced any such oogonia. De Bary says that as many as three eggs may occur in *P. cymosa* but their appearance is evidently of great rarity.

In order to judge of the significance of the peculiar behavior of the spores in *Achlya paradoxa* it will be useful to review the variations in behavior in sexual reproduction in the Saprolegniaceae as recorded in the literature.

In the case of *Achlya* a departure from or modification of the usual grouping of the spores at the sporangium tip has been recorded in a few instances. In the first place it must be remembered that the spores in this genus are not perfectly quiescent during and immediately after emergence. A slight amoeboid motion is observable at all times from their initial formation to the appearance of the encysting membrane. Added to this is a certain feeble jerking and rotation due to the presence of cilia, that has been recorded by several observers since Cornu<sup>8</sup> first described it in 1872. On page 11 of his monograph Cornu says that these cilia have just enough agility to cause the escape of the spores from the sporangium, thus implying that they are the cause of the escape, a point that has been considerably discussed and which I shall take up at another time. The presence of cilia on the emerging spores of *Achlya* is strongly asserted by Hartog<sup>9</sup> who also predicts that they will be found in all species of *Achlya* and *Aphanomyces*.<sup>10</sup>

He also says in the first of these papers that the spores of *Achlya* after forming a ball revolve on their long axils for a short time before the cyst is formed, and that sometimes a few spores will detach themselves and swim away a short distance. In the second paper he says that "When the sporange is discharged near the margin of the hanging drop, or in a thin layer of water on a slide, we constantly see single spores escape from the mass, swim away, and encyst apart." This important observation has been frequently overlooked by subsequent workers, but I can confirm it

<sup>8</sup> Monographie des Saprolegniées. Ann. Sci. Nat. V. 15: 5. 1872.

<sup>9</sup> Quart. Jour. Micr. Sci. 35: 427. 1887.

<sup>10</sup> Ann. Botany 2: 201. 1888.

positively for *Achlya caroliniana*. In this case if the sporangium is put on the slide in a very thin layer of water the spores will swim slowly apart on emerging and scatter themselves over a limited area near the mouth of the sporangium. By addition of iodine solution the cilia were clearly seen. In the case of *Achlya De Baryana*<sup>11</sup> I have recorded the occasional breaking up of the spore mass into scattered groups, but I have not seen any swimming motion in that species. Humphrey in his monograph also demonstrated the presence of cilia on the escaping spores of *Achlya americana*. It will be noted, however, that in none of these cases do any of the spores swim away regularly and under ordinary circumstances. In this respect *Achlya paradoxa* is unique.

In case of bacterial contamination, or foulness from any cause, or where the parts are put in liquid nutrient media, there is strong tendency for the spores to be retained in the sporangium, or if discharged for them to sprout at once without a second swimming stage. There has arisen a loose way of speaking of all sporangia when the spores are retained, or even in part retained, as "Dictyosporangia" a term that should be used, only when spores emerge through the wall of the sporangium and escape for (what is homologous with) the second swimming stage. As one might expect, there is variation in *Dictyuchus* itself in this respect, the spores frequently sprouting by the *Aplanes* method (see below). Variations in the discharge and behavior of the spores are recorded in the following cases:

*Achlya aplanes* Maurizio: Flora 79: 109. 1894. The behavior of the spores in this case is very peculiar. There is no swimming stage, the spores on emerging sprouting into tubes. Frequently they do not emerge at all, but remain in the sporangium and sprout there.

*Achlya caroliniana* Coker: Bot. Gaz. 50: 381. 1910. The spores may be retained and sprout as in *Aplanes*, or under certain circumstances may emerge in a motile condition.

Later observation by me shows that under certain conditions as an egg yolk in 1 per cent.  $\text{KN}_2\text{PO}_4$  the spores may not stick to the sporangium mouth, but fall to the bottom in open order.

<sup>11</sup> MYCOLOGIA 4: 319. 1912.

*Achlya De Baryana* Humphrey (*Achlya polyandra* De Bary): Coker, Mycologia 4: 319. 1912. Figs. 7 and 8, of plate 78, show reduced sporangia with spores in a single row, the spores emerging exactly as in *Dictyuchus*. They also frequently sprout as in *Aplanes*.

*Achlya glomerata* Coker: Mycologia 4: 325. 1912. In fig. 7, plate 79, is shown a sporangium with the spores sprouting as in *Aplanes*.

*Achlya polyandra* Hildebrand: Ward, Quart. Jour. Micr. Sci., 23: 272. 1883. In plate 22, fig. 8, is shown a sporangium with the spores emerging just as in *Dictyuchus*. The retention of the spores in this case he was able to bring about by poor aeration, i. e., placing the culture in on air tight chamber.

*Achlya prolifera* (Nees) De Bary: Bot. Zeit. 10: 473. 1852. In plate 7, fig. 28, is shown the sprouting of the spores at the mouth of the sporangium, the second swimming stage omitted. In all the seven species of *Achlya* that I have studied the second swimming stage may be easily suppressed.

*Achlya racemosa* Hildebrand: Pringsheim, Jahrb. für Wiss. Bot. 9: 191. 1873. In plate 22, figs. 1, 2 and 3, are shown sporangia emptying exactly as in *Dictyuchus*. Under the name of *Achlya lignicola*, which is now regarded as a depauperate condition of *A. racemosa*, Hildebrand figures a sporangium with many of the spores remaining undischarged (Jahrb. für Wiss. Bot. 6: 249, plate 16, fig. 2. 1867).

*Aphanomyces stellatus* De Bary: Sorokin, Ann. Sci. Nat. VI. 3: 46. 1876. In plate 7, figs. 10 and 18, are shown sporangia discharging their spores in the exact manner of *Dictyuchus*. He also shows sprouting at the mouth of the sporangium, and sporangia with spores in more than one row. See also Humphrey (Saprolegniaceae of the U. S., p. 79) for omission of second swimming stage.

*Aplanes androgynus* (Archer) Humphrey (= *Aplanes Braunii* De Bary): Reinsch, Jahrb. für Wiss. Bot. 11: 283. 1877.

Under the name of *Achlya Braunii*, Reinsch states positively

that sporangia occur which show cell nets after the escape of the spores. He also says that in most cases after the emergence of the spores the cell nets are not visible, indicating that they disappear soon. His implication throughout is that the spores always escape as in *Dictyuchus*, and one of his figures (fig. 5, plate 14) clearly shows this method. However, in fig. 2 he shows two sporangia attached to an oogonium which are empty and show distinct openings for the discharge of the spores. In fact Reinsch did not observe at all the "*Aplanes* type" of spore germination as De Bary later described it (Bot. Zeit. 46: 651. 1888). When we remember that De Bary speaks of the sporangia as of great rarity, it seems to me that we are entirely unjustified in asserting that the spores of *Aplanes* have no swimming stage. All of Reinsch's testimony is the other way, and as Fischer says (Kryptogamen Flora von Deutschland, etc., p. 367. 1892) there can be no doubt that Reinsch's plant and De Bary's are the same. In his description of the genus Fischer admits that net sporangia (as in *Dictyuchus*) seem also to occur occasionally.

*Apodachlya pirifera* Zopf: Nova Acta Kel. Leop. Carol. Akad. der Naturforscher 52: 313. 1888. The spores normally encyst at the mouth of the sporangium and then emerge for a swimming stage as in *Achlya*. However, they may, on occasion, swim away in emerging, or they may encyst in part in the sporangium.

*Dictyuchus monosporus* Leitgeb: Jahrb. für Wiss. Bot. 7: 357. 1867-70. In plate 23, fig. 8, is shown a sporangium with spores sprouting after the manner of *Aplanes*. This variation I have many times seen in an undescribed species of *Dictyuchus* that is common at Chapel Hill.

*Leptomitius lacteus* (Roth) Agardh: Humphrey (Saprolegniaceae of the United States, etc.), says on page 136: "While the zoospores ordinarily escape from the sporangia, they sometimes become encysted within them (Fig. 117). It is this fact, probably, which led Braun to state ('51)<sup>12</sup> that the spores of *Lepto-*

<sup>12</sup> This refers to A. Braun. Betrachtungen über die Erscheinung der Vorjüngung in der Natur. Leipzig, 1851. Also translated by Henfrey, Ray Society, London, 1853.

*mitus* are arranged in a row in the spore cases, and that 'no active gonidia seem to occur.'

*Monoblepharis macranda* Woronin: Memoirs de l'Acad. Imp. des Sciences de St. Petersburg. Cl. Phys. Natl. 8th series 16: 1. 1904. In this species some or all of the spores may be retained in the sporangium and sprout there. Normally the zoospores on emerging show amoeboid movements.

*Saprolegnia asterophora* De Bary: Jahrb. für Wiss. Bot. 2: 169. 1860. In plate 20, fig. 25, is shown a partly emptied sporangium, the remaining spores sprouting into tubes.

*Saprolegnia ferax* (Gruith.) Thuret: Ann. Sci. Nat. III. 14: 214. 1850. In plate 22, fig. 8, Thuret shows an unopened sporangium with the spores sprouting in position. This is a good example of the *Aplanes* method.

In the case of a parasite on fish, that he considers *Saprolegnia ferax*, Smith gives a figure showing spores sprouting inside the sporangium at one end while others are swimming out at the other. Such a combination is probably fanciful (Grevillea 6: 152. 1878. The same in Gardener's Chronicle, 4th of May, 1878).

In this same species Pringsheim (Jahrb. für Wiss. Bot. 9: 191. 1874) gives an interesting case (fig. 12, plate 21) of the contents of an egg turning immediately into a sporangium, the spores being retained and sprouting in position. In figs. 1a, b, c, plate 20, he shows spores that had been retained in a partly discharged sporangium. These had sprouted in position to short tubes which became sporangia and discharged small spores.<sup>13</sup>

*Saprolegnia monoica* Pringsheim: Huxley, Quart. Jour. Micr. Sci. 22: 311. 1882. He describes the regular occurrence towards the end of active growth of sporangia of the *Aplanes* type. He calls them, improperly, "dictiosporangia." In this plant, which was a parasite on salmon, it is noteworthy that Huxley found no motion in the spores but only a passive drifting about when discharged. In a similar (probably the same) plant, found as a parasite on fish, Anger (Ann. Sci. Nat. III. 2: 5. 1844)

<sup>13</sup> The assertion by Gerard (Proc. Soc. Nat. Hist. Poughkeepsie, December 18, 1878, p. 25) of the occasional retention of the spores in *Saprolegnia ferax* is probably not based on any original observation.

gives a figure (fig. 11, plate 1) showing a few spores left in the sporangium and sprouting there into long tubes. In this parasite he records the spores as swimming on leaving the sporangium, not floating away as in Huxley's plant.

*Saprolegnia torulosa* De Bary: Lechmere, New Phytologist 9: 305. 1910. In fig. 33, plate 2, is shown a sporangium with spores sprouting after the manner of *Aplanes*. Another example is shown in the same journal 10: 167. 1911, fig. 2, on page 175. In his first paper he shows that the second swimming stage may be suppressed. De Bary in Vergleichende Morphologie und Biologie der Pilze, Leipzig, 1884, says (page 117) that the second swimming stage may be omitted in any species of *Saprolegnia*.

*Saprolegnia* sp.?: Pringsheim, Jahrb. für Wiss. Bot. 2: 205. 1860. In plate 22, fig. 9, is shown a sporangium emptying exactly as in *Dictyuchus*. It is attached to a hypha which also bears a sporangium of the normal *Saprolegnia* type.

In both *Saprolegnia* and *Achlya* it frequently happens that the discharge of the spores is only partial, a few, or even a good many spores being left in the sporangium. These retained spores may emerge from their cysts, as normally, for a second swimming stage, moving about within the sporangium until they find their way out by its mouth. This is shown by Hildebrand for his *Achlya polyandra* (not *A. polyandra* De Bary) (Jahrb. für Wiss. Bot. 6: 249. 1867, plate 16, fig. 2) and by Lechmere for *Saprolegnia torulosa* (?) (New Phytologist 9: 305, plates 1 and 2. 1910, figs. 22, 23, 30, 31. Also in vol. 10, fig. 2, page 175). Lechmere erroneously calls this the *Dictyuchus* type of asexual reproduction. It is doubtful if the species of *Saprolegnia* (a parasite on fish) studied by him in his first paper is *Saprolegnia torulosa*. It is more apt to be the one that Huxley studied (Quart. Jour. Micr. Sci. 22: 311. 1882) and supposed to be *S. monoica*.

Another peculiar and rare variation in the behavior of the sporangial contents is described and figured by Horn (Ann. Myc. 2: 207. 1904) for *Achlya polyandra* De Bary (*A. De Baryana* Humphrey). At a temperature of 31° to 32° Celsius, sporangia were formed which emptied large masses of protoplasm

through several openings. These masses, then, by direct division formed spores, some of usual size ( $10\ \mu$ ), some larger (up to  $40\ \mu$  in diameter). If now brought to room temperature these small spores escaped from their cysts and swam. The larger ones germinated directly. He also mentions the occasional appearance of double spores from normal sporangia. The discharge of large and irregular masses of protoplasm from the sporangia had been figured by Leitgeb as long ago as 1869, for *Saprolegnia monoica* (Jahrb. für Wiss. Bot. 7: 357. 1869-70). In plate 24, fig. 5 he shows several such masses, some with cilia at different points, also several double zoospores. In a species of *Achlya* from Chapel Hill,<sup>14</sup> I have observed several times the emptying of the entire protoplasm from a sporangium at the tip, the mass falling at once to the bottom as a long contorted rope (see above, p. 291). This is still further and conclusive evidence that the spores are discharged by internal pressure and not through their own motion.

It will, of course, be understood that the variations reviewed above are in no sense fortuitous or accidental. They are the results of environmental conditions and many of them may now be induced at will by the investigator. A discussion of my own and other observations in regard to environmental influences on reproduction in this group will be reserved for another place.

In closing this short review of certain variations in the details of sexual reproduction in the group, I feel it necessary to give a word of caution against the attitude adopted by Lechmere in his two papers in the New Phytologist, both of which are referred to above. In the summary of his first paper he says that "As the result of keeping a species of *Saprolegnia* under observation for a period of five months it has been found possible to obtain on the same mycelium the methods of asexual reproduction which are characteristic of six different genera." If this claim is examined it will be seen that outside of its own genus (*Saprolegnia*) the species he describes cannot with accuracy be said to show the methods of a sexual reproduction of any other genera except *Aplanes* and *Leptolegnia*, and even in these cases only in certain

<sup>14</sup>A probable hybrid. See Journal Elisha Mitchell Scientific Society 30: 63. 1914.

details, not in all. The sporangial variations cited do not look like the sporangia of the genera in question and neither do the spores within them; and no one familiar with these genera would be misled into placing them there unless one's attention be focused on the wording of keys rather than on the plants themselves. Such variations as these do not create doubt, as Lechmere implies, on the validity of the presently accepted classification of the Saprolegniaceae. The occasional appearance of a soft-shelled egg in a hen's nest does not shake our faith in the reality of the distinction between a hen and a lizard.

Unless it be *Achlya paradoxa*, I know of no species whose genus could be in doubt after an adequate study of its asexual reproduction alone.

UNIVERSITY OF NORTH CAROLINA,  
CHAPEL HILL, N. C.

## EXPLANATION OF PLATES CXLVI-CXLVIII

All drawings were made with the aid of the camera lucida.

## PLATE CXLVI

*Achlya paradoxa* sp. nov.

1. A group of empty sporangia of normal appearance.  $\times 335$ .
2. A group of sporangia showing both lateral and internal proliferation.  $\times 335$ .
3. Another example of the above.  $\times 335$ .
4. A sporangium with spores killed during exit, showing the cilia.  $\times 335$ .
5. An oögonium with base intercalated in a hypha. The projection below is not usual. An antheridium was present, but is not shown.  $\times 335$ .
- 6, 7 and 8. Typical oögonia with antheridia.  $\times 335$ .
- 9 and 10. Chlamydospores.  $\times 335$ .

## PLATE CXLVII

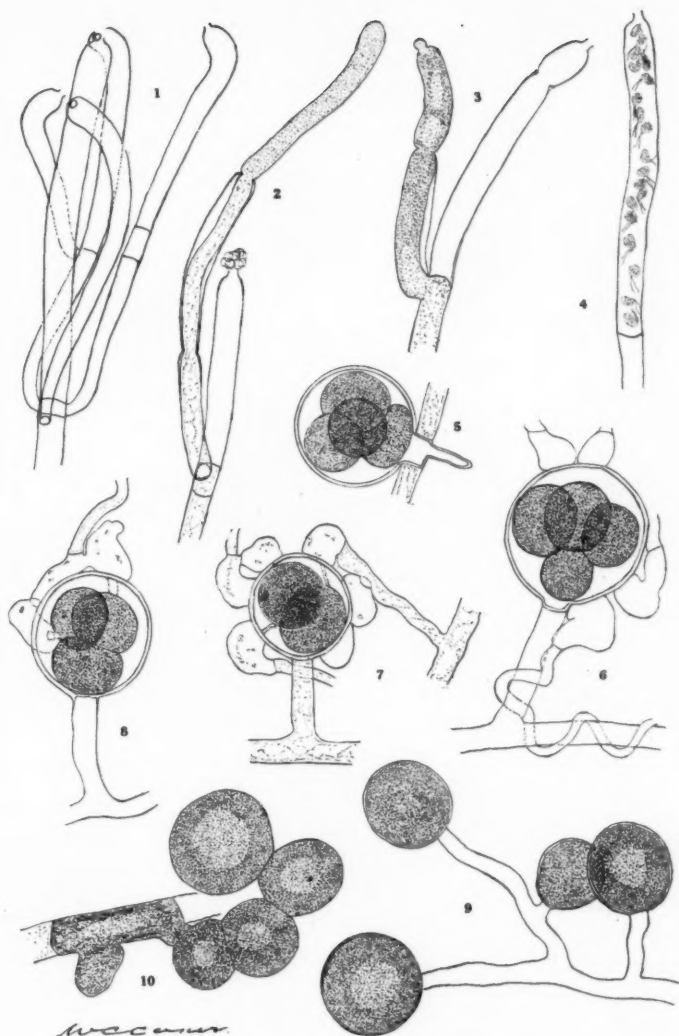
*Pythiopsis cymosa* De Bary

1. Oögonium with a typical sub-basal antheridium.  $\times 720$ .
2. Ditto, with an additional lateral antheridium.  $\times 720$ .
3. Ditto, with two sub-basal antheridia.  $\times 720$ .
- 4, 5, 6 and 7. Oögonia of various forms with antheridia of various origin.  $\times 720$ .
8. An abnormal double oögonium, apparently without an antheridium.  $\times 720$ .
9. Sporangia of typical shapes.  $\times 447$ .
10. Sporangia about one minute before discharge showing the spores in the compression stage.  $\times 447$ .
- Chlamydospores; one having discharged spores by a basal papilla.  $\times 447$ .
12. Spores, killed while swimming; one with four cilia and double size.  $\times 720$ .

## PLATE CXLVIII

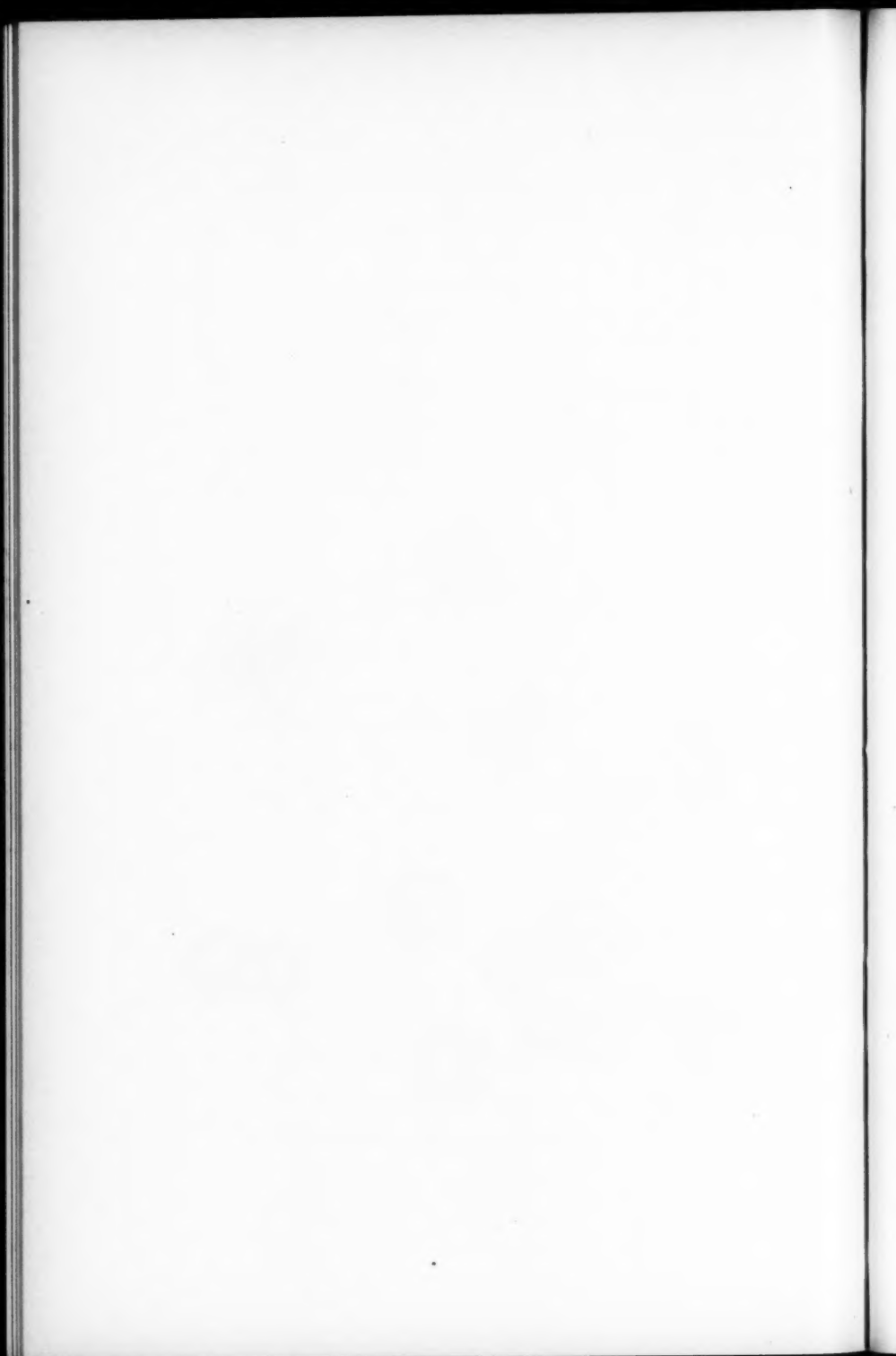
*Pythiopsis Humphreyana* sp. nov.

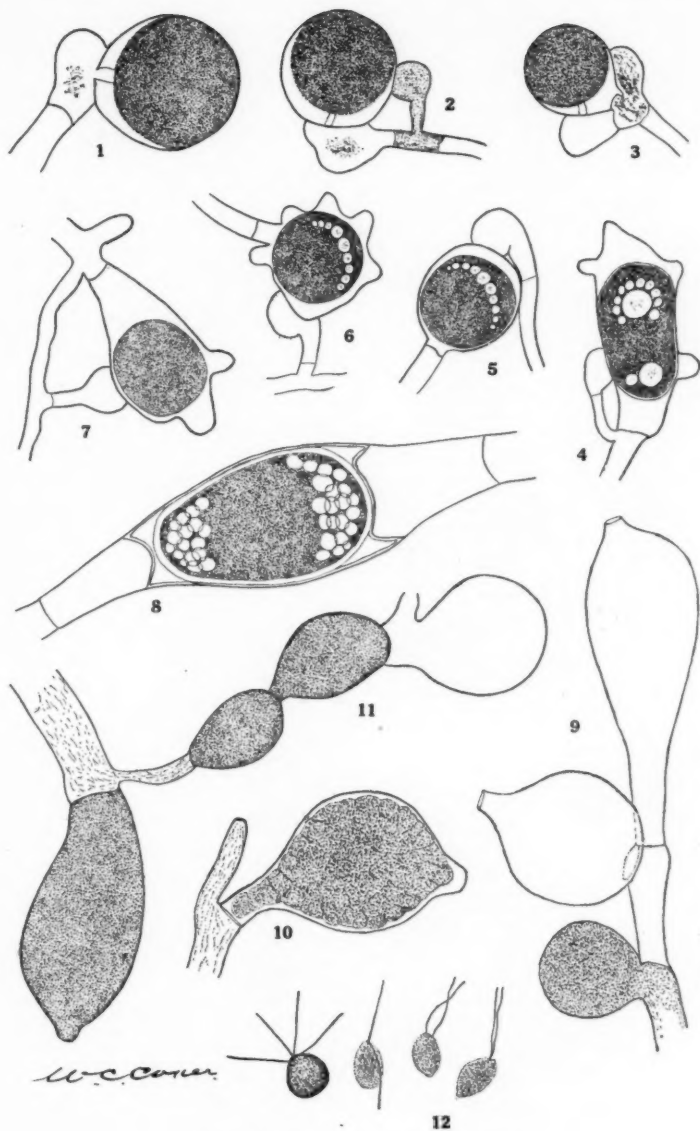
1. Sporangia of the globular form.  $\times 335$ .
2. Two sporangia with an oögonium and antheridium.  $\times 335$ .
- 3, 4, 5, 6, 7, 8, 9 and 10. Sporangia of various forms. Nos. 3 and 4  $\times 185$ ; others  $\times 125$ .
11. A sporangium, surrounded with several oögonia.  $\times 185$ .
12. Two sporangia, with oögonia in close proximity.  $\times 185$ .
13. A young oögonium with antheridium.  $\times 335$ .
14. An oögonium with two eggs and two antheridia, one of which is diclinous.  $\times 335$ .
15. Another oögonium with a diclinous antheridium, showing plainly the antheridial tube.  $\times 335$ .
16. An abnormal oögonium with four eggs.  $\times 335$ .



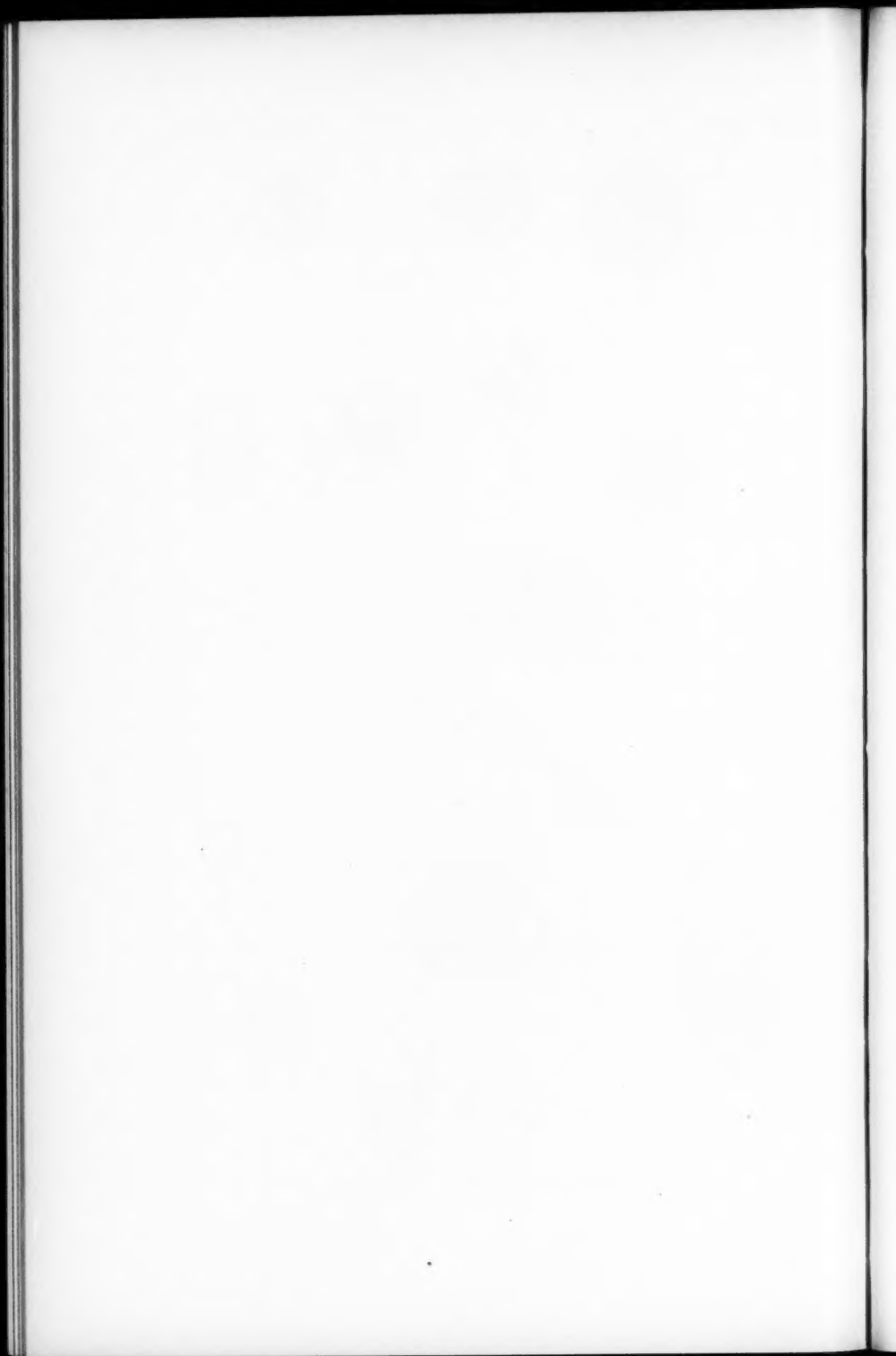
*W. Coker*

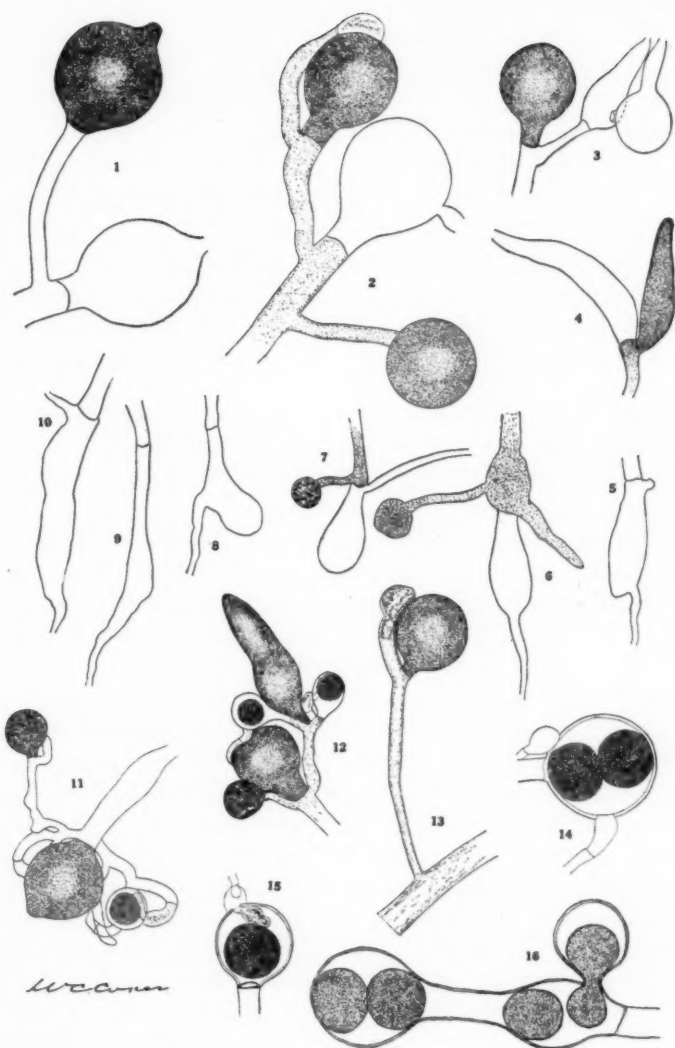
ACHLYA PARADOXA COKER





PYTHIOPSIS CYMOSA DE BARY





PYTHIOPSIS HUMPHREYANA COKER



## NEWS AND NOTES

Mr. S. M. Zeller, formerly of the botanical department of the University of Washington at Seattle, now holds a research fellowship at the Missouri Botanical Garden in St. Louis.

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Mr. Guy West Wilson, formerly forest pathologist at New Brunswick, New Jersey, has been appointed assistant professor of mycology and plant pathology in the State University of Iowa at Iowa City.

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Dr. F. D. Kern, professor of botany at State College, Pennsylvania, visited the Garden on September 5-8 to examine the herbarium, library, and collections of living plants under glass.

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Dr. C. J. Humphrey, forest pathologist at the Products Laboratory, Madison, Wisconsin, visited the Garden on October 23 to consult the collection of polypores. He intends to spend part of December in Cuba collecting fungi.

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Professor Guy W. Wilson calls attention to an error in his paper on *Phytophthora* published in MYCOLOGIA last March. On pages 73 and 80, *Phleophythora* is incorrectly used for *Phloeophthora*. Klebahn's paper on "Eine Neue Pilzkrankheit" (Cent. Bakt. II. 15: 335. 1905) should also be added to the bibliography.

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Dr. Howard J. Banker, who has been professor of botany in De Pauw University for the past ten years, recently resigned his position to become a special investigator with the Eugenics Record Office at Cold Spring Harbor, New York. He will enter upon his new duties on October 1. Dr. Donald W. Davis succeeds Dr. Banker at De Pauw.

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Mr. J. R. Johnston, who has made extensive investigations of coconut and sugar cane diseases in tropical America, spent Au-

gust 10-12 at the Garden consulting the herbarium and library. He has resigned his position with the Porto Rico Sugar Growers' Association at Rio Piedras, Porto Rico, to accept the position of plant pathologist in the agricultural experiment station at Santiago de las Vegas, Cuba.

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A manual entitled "Northern Polypores" has just been published by Dr. W. A. Murrill, which contains descriptions of all the pileate species found in North America east of the Rocky Mountains and north of North Carolina. Keys and notes accompany the descriptions. Similar manuals by Dr. Murrill entitled "Southern Polypores," "Western Polypores," "Tropical Polypores," and "American Boletes" are expected to appear within a short time.

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Dr. Arthur Harmount Graves has resigned his position as assistant professor of botany in the Sheffield Scientific School of Yale University, and is at present engaged in research at the laboratory of Dr. V. H. Blackman, professor of plant physiology and pathology at the Royal College of Sciences, South Kensington, London, England. Dr. Graves has been a member of the faculty of Yale for the last twelve years. His present address is, Care of Brown, Shipley & Co., 123 Pall Mall, London, England.

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Dr. W. A. Murrill visited Washington and parts of Virginia during the latter part of September and collected a number of fungi of interest. He found the two poisonous species *Ven-narius phalloides* and *Clitocybe illudens* especially abundant, the latter growing in open fields as well as in woods, about old stumps and buried roots. All of the woodlands were found to be infected with the chestnut canker, which caused the death of many individual branches this season, but is expected to do the greatest damage in the next two or three years. As a large percentage of the timber about Washington is chestnut, the loss will be very considerable.

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The Underwood Collection of Fungi, containing 17,000 specimens, was purchased by the New York Botanical Garden in July,

1914. In addition to valuable sets of published exsiccati, it contains a full representation of all the fungi collected by the late Lucien M. Underwood at Auburn, Alabama; Greencastle, Indiana; Syracuse, Kirkville, Jamesville, and Clyde, New York; West Goshen and Redding, Connecticut; and at many points in and about New York City. There are also miscellaneous specimens from many parts of North America, either collected by Dr. Underwood in his travels or sent in by collectors for determination. All groups of fungi are well represented in this collection and the specimens are well preserved. Many of them are valuable types.

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